US009421956B2

(12) **United States Patent**
Kahn et al.

(10) **Patent No.: US 9,421,956 B2**
(45) **Date of Patent: Aug. 23, 2016**

(54) **VEHICLE BRAKING ASSEMBLY**

(71) Applicant: **Ford Global Technologies, LLC**, Dearborn, MI (US)

(72) Inventors: **Adil Kahn**, Lakeshore (CA); **Clement Sagan**, Dearborn, MI (US); **Dale Scott Crombez**, Livonia, MI (US); **Daniel A. Gabor**, Canton, MI (US); **Daniel Anthony Villar**, Canton, MI (US); **Mark Muddiman**, Belleville, MI (US); **Prashanth Kaparthi**, Canton, MI (US)

(73) Assignee: **Ford Global Technologies, LLC**, Dearborn, MI (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 201 days.

(21) Appl. No.: **14/064,444**

(22) Filed: **Oct. 28, 2013**

(65) **Prior Publication Data**

US 2014/0041470 A1 Feb. 13, 2014

Related U.S. Application Data

(62) Division of application No. 12/629,752, filed on Dec. 2, 2009, now Pat. No. 8,607,660.

(51) **Int. Cl.**

G05G 1/30	(2008.04)
B60T 11/18	(2006.01)
B60T 7/06	(2006.01)
G05G 1/40	(2008.04)
G05G 1/46	(2008.04)
G05G 23/02	(2006.01)

(52) **U.S. Cl.**
CPC . ***B60T 11/18*** (2013.01); ***B60T 7/06*** (2013.01); ***G05G 1/40*** (2013.01); ***G05G 1/46*** (2013.01); ***G05G 23/02*** (2013.01); *Y10T 29/49826* (2015.01); *Y10T 74/1896* (2015.01); *Y10T 74/20528* (2015.01)

(58) **Field of Classification Search**
CPC G50G 1/30; B60T 11/18; B60T 7/06; G05G 23/02; G05G 1/40; G05G 1/46; Y10T 74/20528; Y10T 74/1896; Y10T 29/49826
USPC 74/512–514; 303/113.3; 188/72.7, 210
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2,834,184	A	*	5/1958	Ingres	60/553
3,113,489	A		12/1963	Cruse et al.	
3,199,298	A		8/1965	Brown et al.	
3,798,995	A	*	3/1974	Schroter	74/512
3,838,629	A		10/1974	Meyers	
4,026,164	A	*	5/1977	Mozingo	74/478
4,283,994	A		8/1981	Belart	

(Continued)

FOREIGN PATENT DOCUMENTS

EP	0229350	A2	7/1987
FR	2887837	A1	1/2007

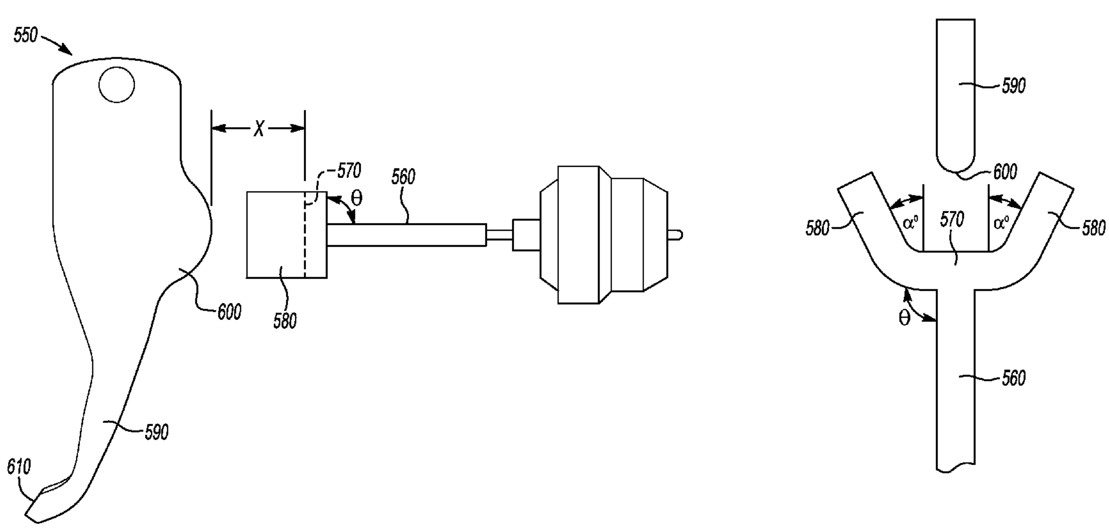
(Continued)

Primary Examiner — Adam D Rogers
(74) *Attorney, Agent, or Firm* — Raymond L. Coppiellie; Brooks Kushman P.C.

(57) **ABSTRACT**

The present disclosure relates to various vehicle braking assemblies. Brake pedal arms include, for example, a cam block that is configured to simplify the engagement between the power booster and pedal arm. Cam block can be movable with respect to the pedal arm to manage the gap between the pedal arm and power booster in by-wire braking assemblies.

6 Claims, 7 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

4,508,009	A	4/1985	Shimamura et al.	
4,565,067	A	1/1986	Tami et al.	
4,599,924	A	7/1986	Klostermann et al.	
4,658,660	A	4/1987	Parker	
4,672,860	A	6/1987	Parker	
4,708,028	A	11/1987	Pardy	
6,155,385	A	12/2000	Basnett	
6,553,864	B1	4/2003	Ersoy et al.	
7,017,441	B2 *	3/2006	Hayashihara et al.	74/512
7,111,703	B2	9/2006	Endo et al.	
7,228,758	B2 *	6/2007	Fujiwara	74/512
7,322,269	B2	1/2008	Faller et al.	
7,409,889	B2	8/2008	Hurwie et al.	
7,584,683	B2 *	9/2009	Fujiwara	74/516
8,607,660	B2 *	12/2013	Khan et al.	74/512
8,646,357	B2 *	2/2014	Khan et al.	74/560
2003/0075005	A1	4/2003	Schiel et al.	
2004/0071817	A1	4/2004	Fischer et al.	
2007/0193394	A1	8/2007	Collins	
2008/0047386	A1	2/2008	Ridgway et al.	
2008/0196983	A1	8/2008	Von Hayn et al.	
2009/0001805	A1 *	1/2009	Schick et al.	303/9.61
2009/0229402	A1 *	9/2009	Khan	B60T 1/10 74/512

FOREIGN PATENT DOCUMENTS

JP	05185912	A	*	7/1993
JP	2004131065	A		4/2004

* cited by examiner

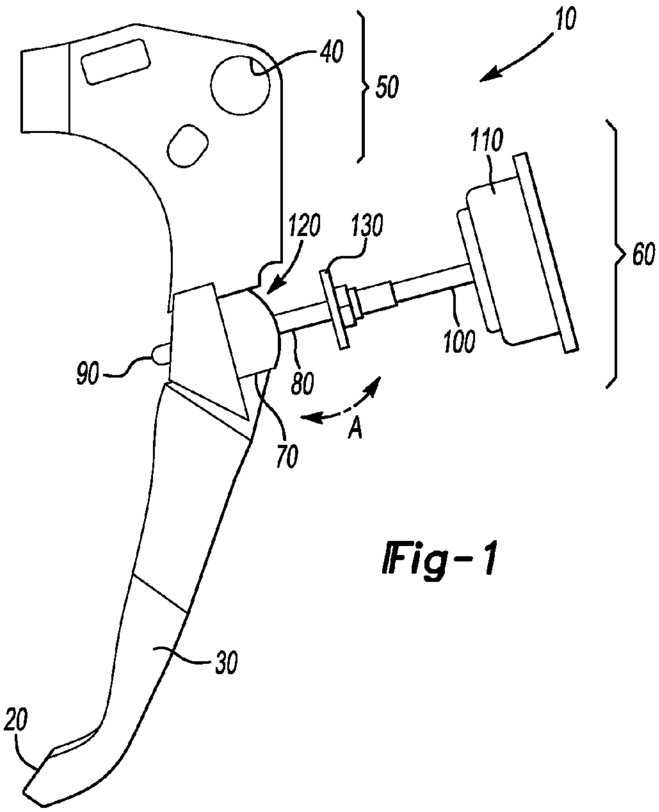

10
40
50
110
120
130
60
90
80
100
A
70
30
20

Fig-1

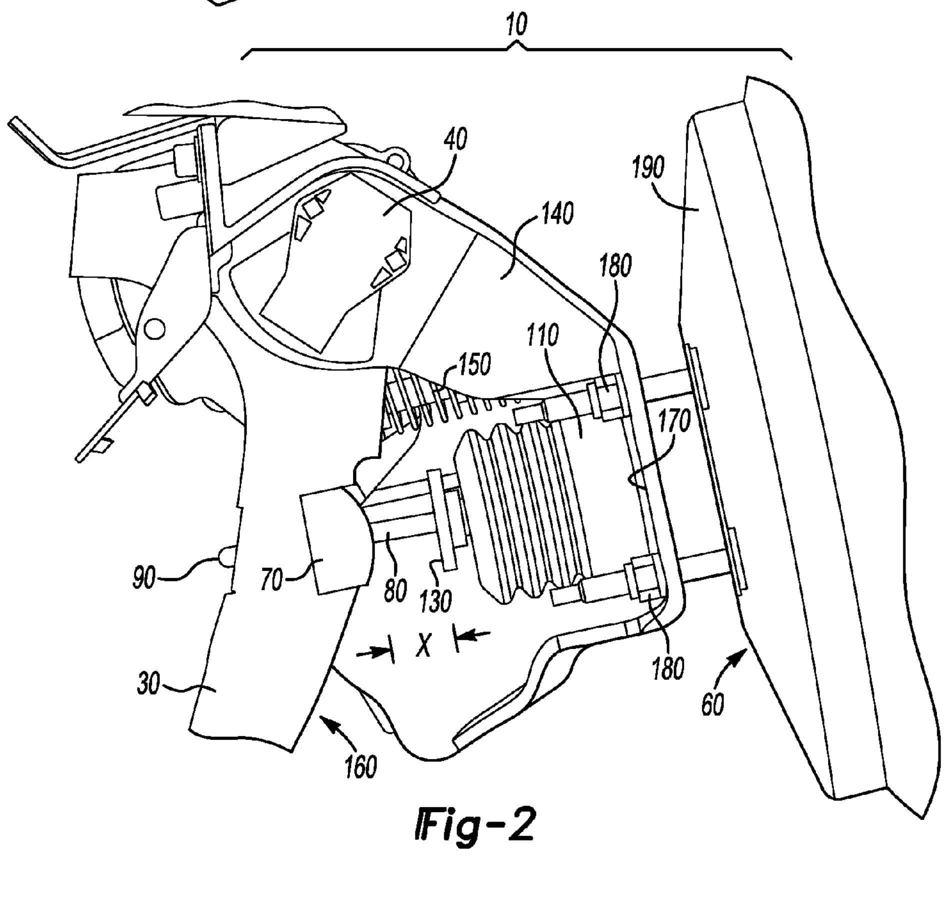

10
40
140
190
180
110
150
170
90
70
80
130
X
180
30
160
60

Fig-2

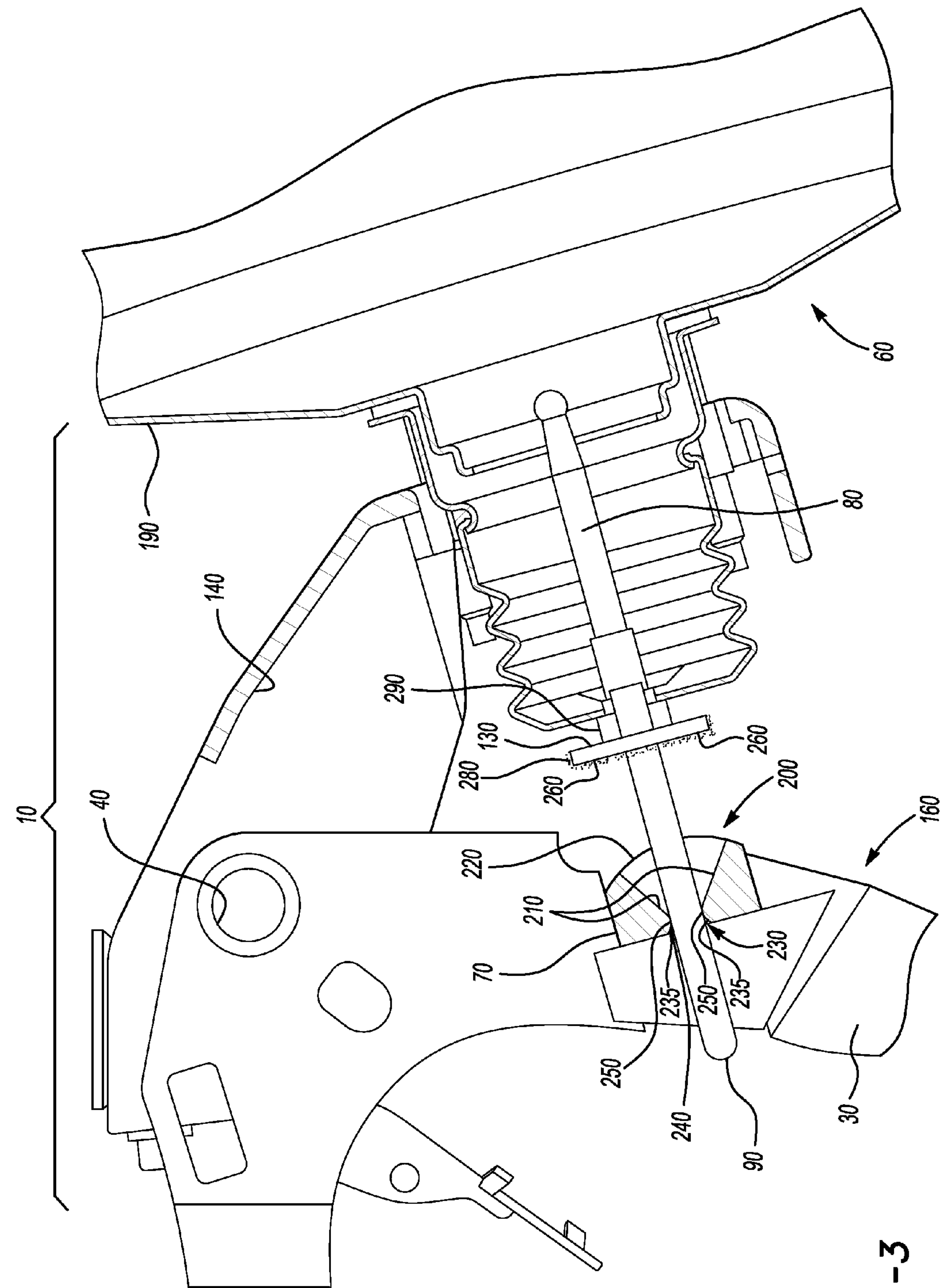
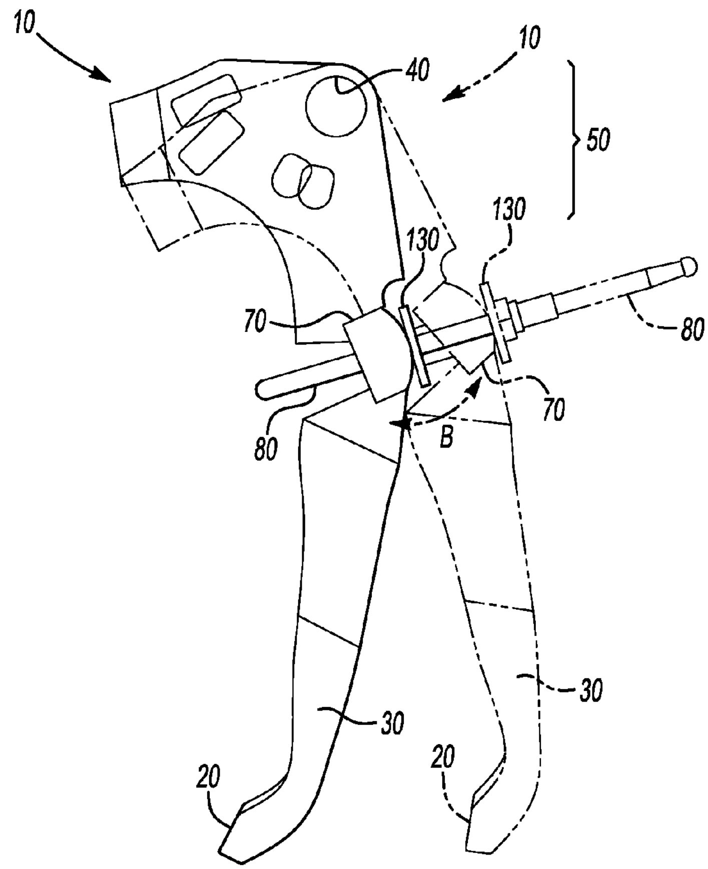
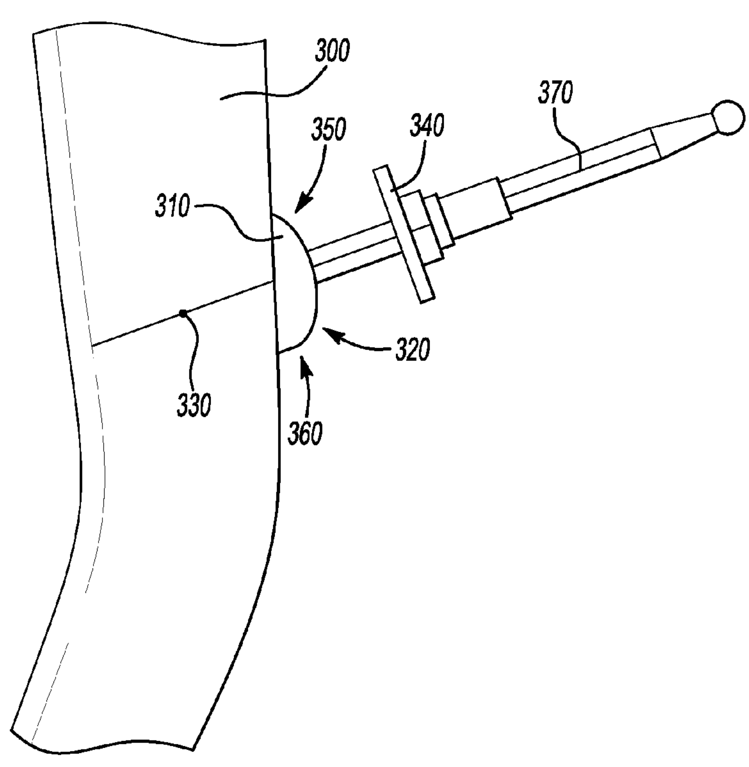

60
80
190
140
10
290
130
280
260
260
200
160
40
220
210
70
230
235
250
235
250
240
90
30

Fig-3



10
10
40
50
130
130
70
80
70
B
80
30
30
20
20

Fig-4



300
370
350
340
310
320
330
360

Fig-5

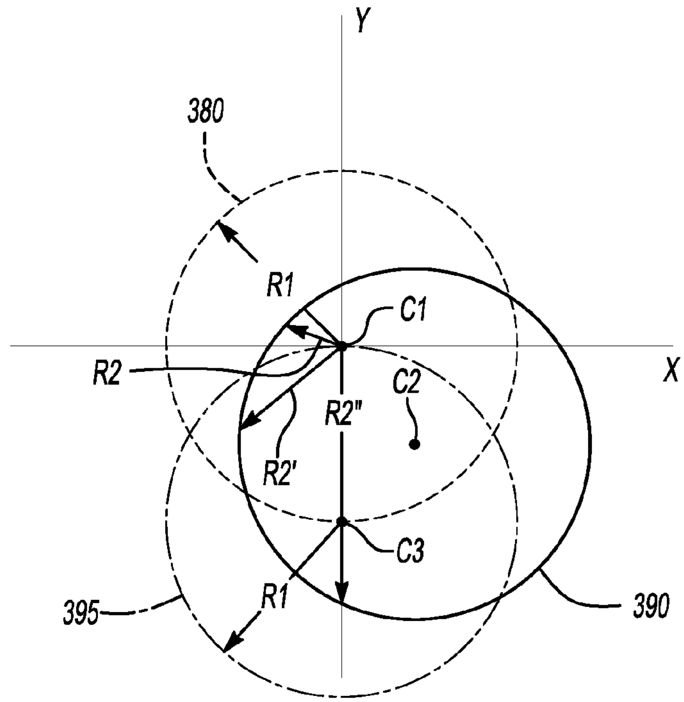

Y
380
R1
C1
X
R2
C2
R2"
R2'
C3
R1
395
390

Fig-6

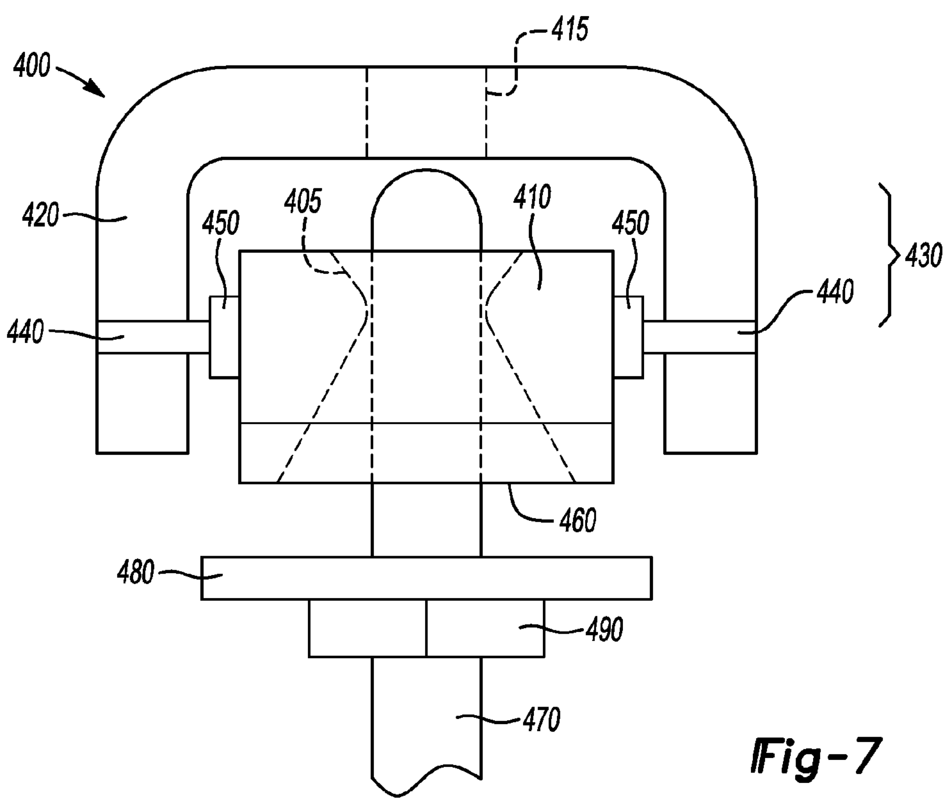

415
400
420
405
410
450
450
430
440
440
460
480
490
470

Fig-7

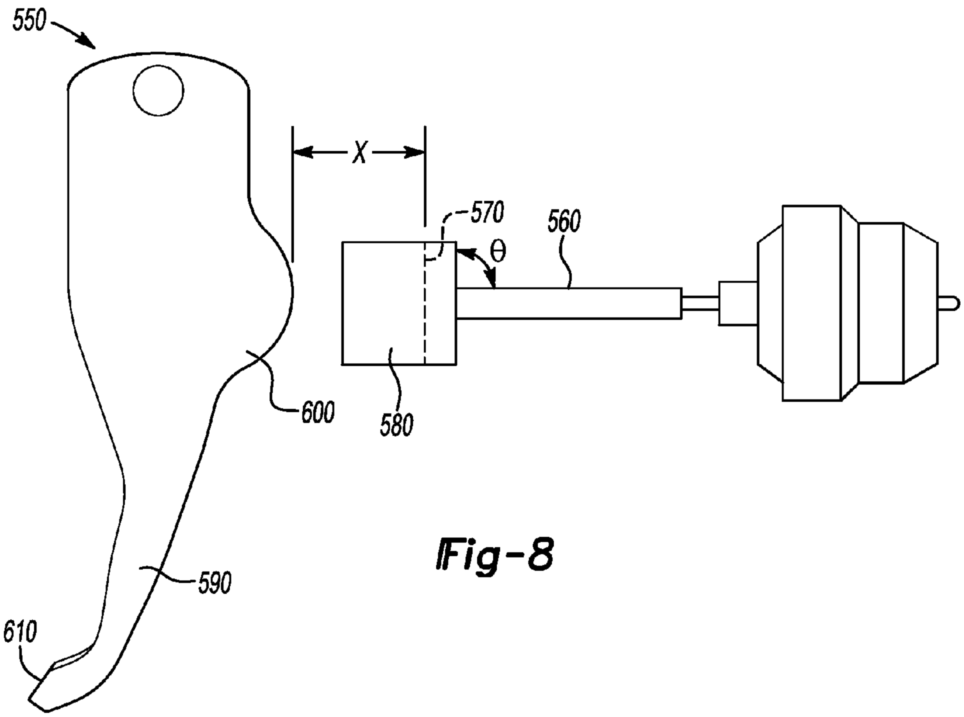


Fig-8

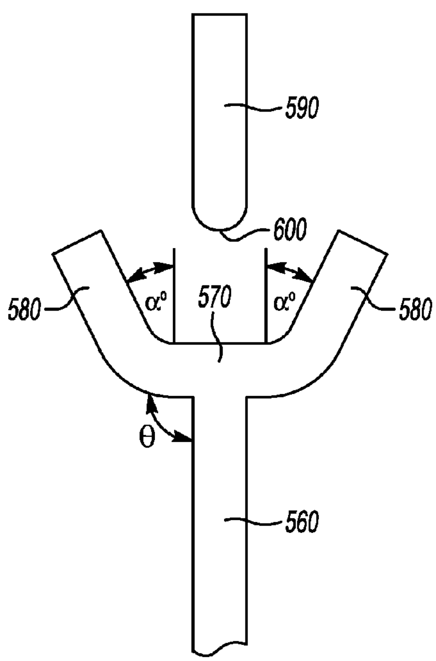


Fig-9

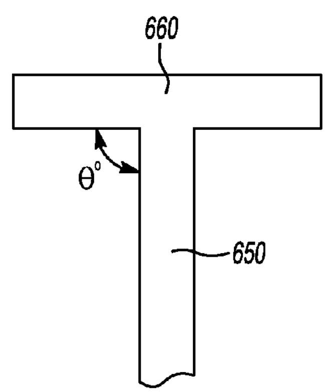


Fig-10

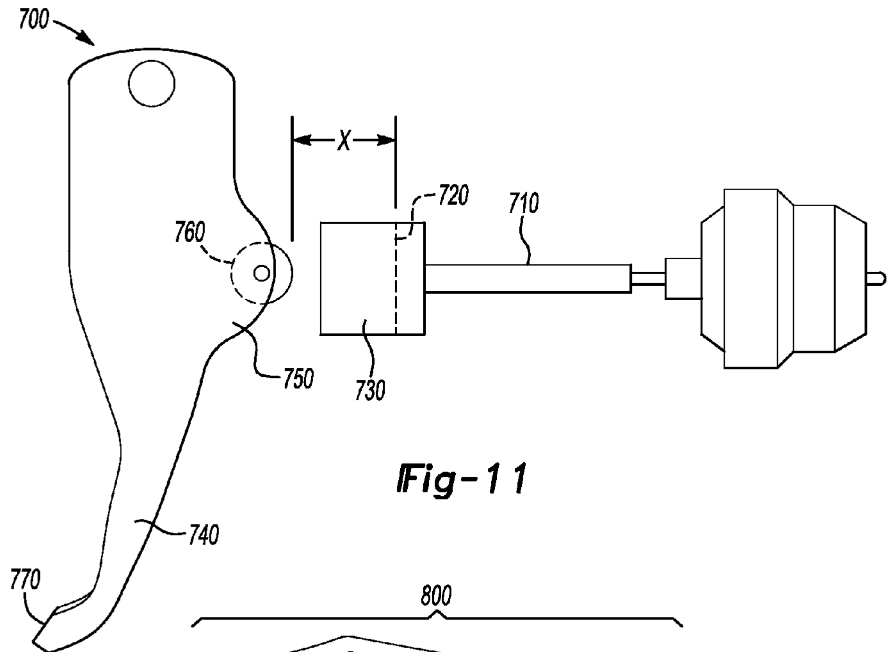

700
X
720
710
760
750
730
740
770

Fig-11

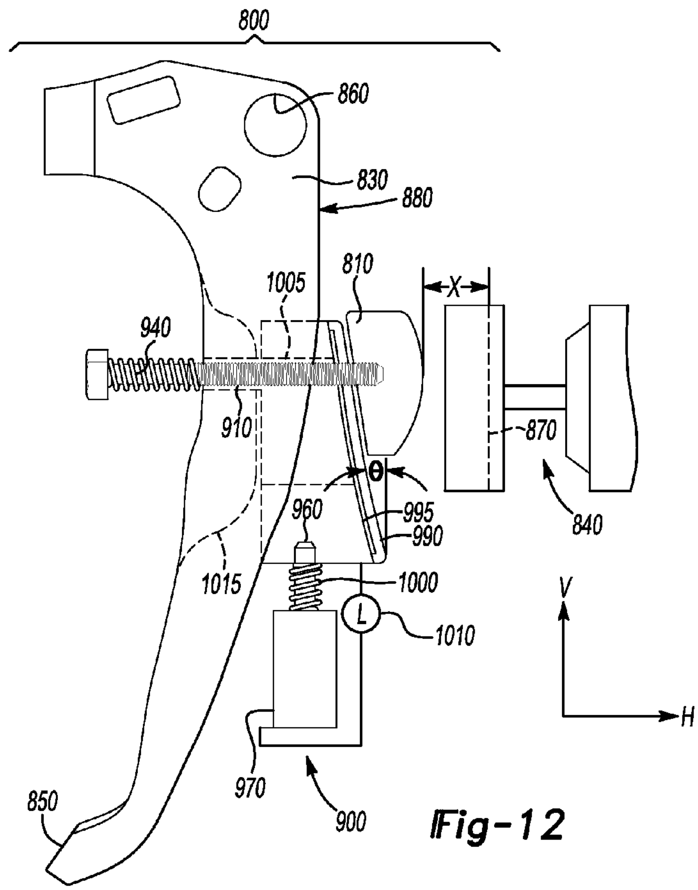

800
860
830
880
810
1005
X
940
910
870
θ
960
995
990
840
1015
1000
V
L
1010
H
970
850
900

Fig-12

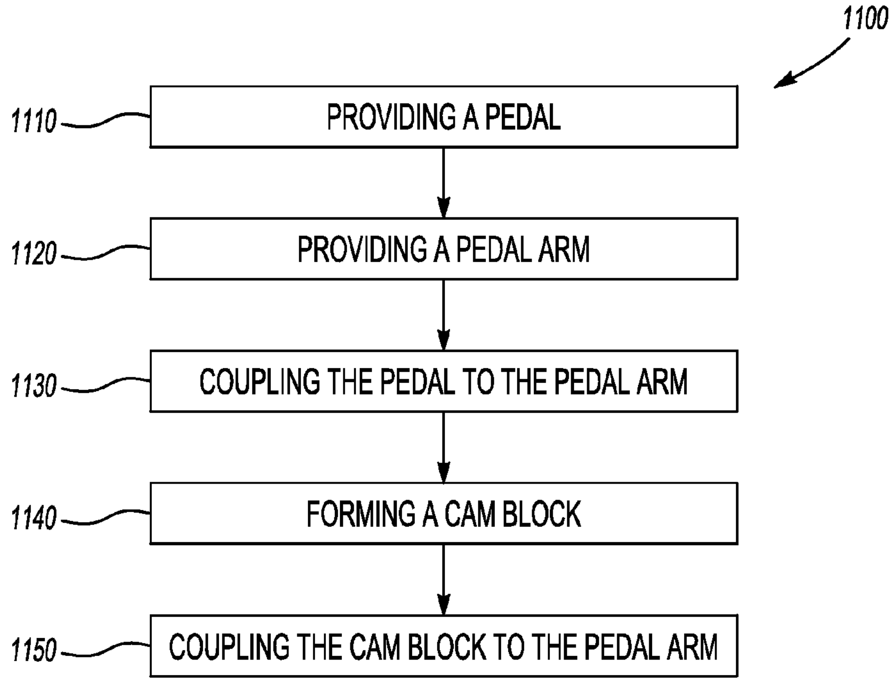

1100
1110
PROVIDING A PEDAL
1120
PROVIDING A PEDAL ARM
1130
COUPLING THE PEDAL TO THE PEDAL ARM
1140
FORMING A CAM BLOCK
1150
COUPLING THE CAM BLOCK TO THE PEDAL ARM

Fig-13

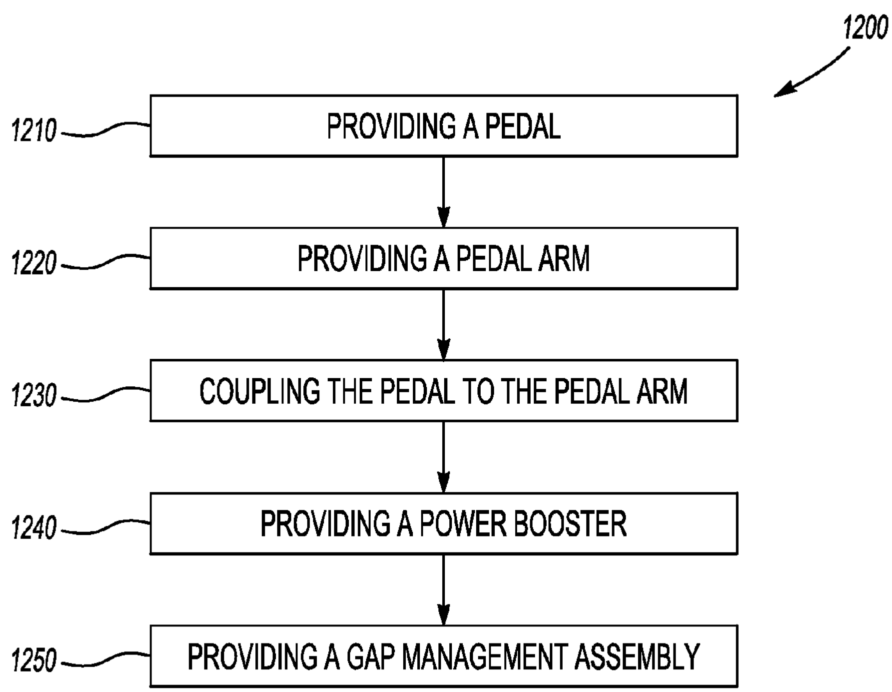

1200
1210
PROVIDING A PEDAL
1220
PROVIDING A PEDAL ARM
1230
COUPLING THE PEDAL TO THE PEDAL ARM
1240
PROVIDING A POWER BOOSTER
1250
PROVIDING A GAP MANAGEMENT ASSEMBLY

Fig-14

VEHICLE BRAKING ASSEMBLY

CROSS-REFERENCE TO RELATED APPLICATION

This application is a division of U.S. application Ser. No. 12/629,752 filed Dec. 2, 2009, now U.S. Pat. No. 8,607,660, the disclosure of which is incorporated in its entirety by reference herein.

TECHNICAL FIELD

The present disclosure relates to vehicle braking assemblies. Various pedal-booster engagements for the braking assemblies are discussed herein.

BACKGROUND

Contemporary vehicles include various braking systems that enable the operator to stop the vehicle by applying pressure to a brake pedal. Vehicle braking assemblies include a pedal with arm connected to the braking system. A power booster can be positioned with respect to the pedal arm; the power booster amplifies the braking force provided by the pedal arm. It is standard to include a clevis pin connected to the pedal arm and a clevis attached to the pedal booster. The clevis assembly guides the pedal arm into alignment and with engagement with the power booster. Conventional hybrid electric vehicles include by-wire braking assemblies having clevis assemblies. Such assemblies, however, can be very complex to install. Moreover, the parts for the clevis assembly can increase the end-item part costs for the vehicle braking assembly.

U.S. Patent Application Publication No. 20070193394—for example—discloses a push rod bracket assembly that includes a booster clevis having a pushrod support wall, with a booster push rod extending outward therefrom into engagement with the booster assembly. Extending away from the pushrod support wall are two legs, a retainer clevis leg and a slotted clevis leg. The retainer clevis leg mounts on a first side of the brake pedal arm and includes a pin hole that aligns with the bracket attachment hole. This assembly still requires the basic components of a clevis assembly which can be costly to produce and install.

Existing attempts to remove the clevis assembly from the braking system require parts that are similarly complicated. For example, U.S. Pat. No. 7,409,889 discloses an arrangement in which an end of a booster control rod has a head and a spherical bearing surface is housed in a complementary boss formed in a wall of the intermediate part of the booster actuating bar. A retaining pin is used to couple the booster rod to the pedal arm. Though this assembly does not require a traditional clevis, the assembly is complicated and adds production and manufacturing costs to the vehicle as well.

Therefore, it is desirable to reduce part complexity for the braking assembly by reducing the number of end-item parts to the plant. It is beneficial to provide a simpler engagement between the power booster rod and brake pedal arm to reduce the production and manufacturing costs of the vehicle.

Other considerations also come into play when designing a by-wire vehicle braking system. In vehicles having regenerative braking systems there can be a gap defined between the brake pedal arm and hydraulic booster interface to allow for at least some of the rotational energy in the wheels to be harvested. This gap can be of larger or smaller sizes to accommodate different vehicle specifications. Where there is a failure in the by-wire braking system, the gap is undesirable and can unnecessarily delay the application of the hydraulic braking system. In by-wire braking systems that decouple the brake pedal from the active booster the gap between the booster and the pedal needs to be overcome if the system is no longer able to operate in by-wire mode. The resulting brake pedal travel is undesirable.

It is also desirable to provide a gap management device for a by-wire braking system. It would be beneficial to have a brake pedal assembly in which the spacing between the pedal arm and power booster can be adjusted for different vehicle conditions. In the case of by-wire system failure, it is desirable to have a braking assembly that closes the spacing between the pedal arm and the hydraulic booster interface.

SUMMARY

The present invention may address one or more of the above-mentioned issues. Other features and/or advantages may become apparent from the description which follows.

Accordingly to one exemplary embodiment of a braking assembly includes: a brake pedal, a pedal arm coupled to the brake pedal; a cam block attached to the pedal arm; and a power booster configured to engage the cam block when the brake pedal is applied a predetermined amount. The booster includes a push rod configured to extend into the cam block. The cam block includes a tapered surface configured to guide a push rod in the cam block.

Another exemplary embodiment relates to a by-wire braking assembly, comprising: a brake pedal; a pedal arm coupled to the brake pedal; a cam surface coupled to the pedal arm; a power booster configured to engage the cam surface when the brake pedal is applied a predetermined amount; and a push rod included in the power booster, configured to linearly move when engaging the cam surface.

According to another exemplary embodiment, a method of manufacturing a vehicle braking assembly is provided. The method includes: providing a pedal; providing a pedal arm configured to pivot with respect to the vehicle; coupling the pedal to the pedal arm; forming a cam block configured to engage a power booster; and coupling the cam block to the pedal arm.

Some of the advantages of the present invention(s) are that they eliminate the need for an assembly operator to insert a clevis/booster/pedal pin. Packaging constraints are less limiting. The present invention also presents significant cost and possible weight reduction.

The present invention(s) reduce part complexity for the braking assembly by reducing the number of end-item parts to the plant. The present teachings also provide a simpler engagement between the power booster rod and brake pedal arm to reduce the production and manufacturing costs of the vehicle.

Another advantage of the present invention(s) is that they provide a gap management device for a by-wire braking system. The gap management device enables the braking assembly to be integrated into multiple vehicle platforms. Moreover, in the case of by-wire system failure, the braking assembly closes the spacing between the pedal arm and the hydraulic booster interface to reduce the response time of the hydraulic braking system.

When the clevis/pedal pin is not appropriately inserted into the pedal arm the pin can fall out of alignment during vehicle operation. The present invention(s) also eliminate the failure mode of the clevis/pedal pin not being inserted or being incorrectly inserted into the pedal arm.

Other advantages of the present teachings are that the cam surface provides a longer booster/master cylinder stroke for

the same pedal travel. The cam surface also provides a variable ratio pedal. In some embodiments, the cam surface includes a tapered inner surface (e.g., a conical or funnel shaped opening). The tapered surface provides easier assembly particularly if the booster is mounted on the vehicle after the brake pedal assembly.

Another advantage of the present invention(s) is that pedal ratio is not significantly affected by changes in the position of the push rod. The position of the push rod can be changed without the changing the cam surface to reduce the articulation of the booster push rod. Therefore, the push rod can still rotate within the same arc of rotation (e.g., +/−3 degrees).

In the following description, certain aspects and embodiments will become evident. It should be understood that the invention, in its broadest sense, could be practiced without having one or more features of these aspects and embodiments. It should be understood that these aspects and embodiments are merely exemplary and explanatory and are not restrictive of the invention.

The invention will be explained in greater detail below by way of example with reference to the figures, in which the same references numbers are used in the figures for identical or essentially identical elements. The above features and advantages and other features and advantages of the present invention are readily apparent from the following detailed description of the best modes for carrying out the invention when taken in connection with the accompanying drawings. In the figures:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a side view of a vehicle braking assembly with power booster according to an exemplary embodiment of the present invention.

FIG. **2** is a partial cross-sectional view of the vehicle braking assembly of FIG. **1**.

FIG. **3** is another cross-sectional view of the vehicle braking assembly of FIG. **1**.

FIG. **4** is a side view of the pedal arm and power booster rod of FIG. **1**, traveling from a first position to a second position.

FIG. **5** is a side view of a brake pedal arm with cam block according to another exemplary embodiment of the present invention.

FIG. **6** is a schematic diagram of the side profile of two cam blocks with respect to a pedal arm.

FIG. **7** is a top view of a vehicle braking assembly according to another exemplary embodiment of the present invention.

FIG. **8** is a side view of a vehicle braking assembly according to another exemplary embodiment of the present invention.

FIG. **9** is a top view of the power booster rod shown in FIG. **8**.

FIG. **10** is a top view of a power booster rod according to another exemplary embodiment of the present invention.

FIG. **11** is a side view of a vehicle braking assembly according to another exemplary embodiment of the present invention.

FIG. **12** a side view of a vehicle braking assembly with movable cam block according to another exemplary embodiment of the present invention.

FIG. **13** is a flowchart illustrating a method of manufacturing a vehicle braking assembly according to an exemplary embodiment of the present invention.

FIG. **14** is a flowchart illustrating a method of manufacturing a vehicle braking assembly according to an exemplary embodiment of the present invention.

DETAILED DESCRIPTION

Referring to the drawings, FIGS. **1**-**14**, wherein like characters represent the same or corresponding parts throughout the several views there is shown several exemplary vehicle braking assemblies according to the present invention. The provided vehicle braking assemblies eliminate the need for a clevis and clevis pin in the booster-to-pedal-arm engagement. Several exemplary mechanical cam blocks, configured to engage the power booster are illustrated and described herein. The cam blocks discussed provide a simpler, less expensive design and are easier to manufacture and assemble.

Referring now to FIG. **1**, there is shown therein a side view of a vehicle braking assembly **10** according to one exemplary embodiment of the present invention. The shown braking assembly **10** is a by-wire system that also incorporates hydraulic braking. The assembly includes a mechanical pedal **20** proximate a vehicle floor (not shown) that is coupled to a pedal arm **30**. Pedal arm **30** is attachable to a vehicle structure at **40**. The pedal arm is **30** configured to rotate with respect to the vehicle about the upper end **50** of the pedal arm. A vehicle operator can apply pressure to the pedal **20** to initiate braking. The pedal arm **30** includes features that enable the pedal arm to engage with a power booster assembly **60** when the pedal **20** is sufficiently pressed. In the illustrated embodiment of FIG. **1**, the pedal arm **30** is shown in an unapplied (or non-pressed) position.

Formed into the pedal arm **30** is a cam block **70**, as shown in FIG. **1**. Cam block **70** is attached to the pedal arm **30** and coupled thereto. Cam block **70** is configured to engage the power booster **60**. In the shown embodiment, the cam block **70** is configured to engage a power booster push rod **80**. Rod **80** extends through the cam block **70** when the pedal **20** is not applied (as shown in FIG. **1**). The push rod **80** is long enough so that, with the pedal arm **30** in the unapplied position or upmost position and the booster or master cylinder in the maximum full stroke condition, the rod is still at least partially captured in the cam block **70** as shown. In this manner, the push rod **80** and cam block **70** cannot disengage even when in the worst or most distant conditions. A first end of rod **90** is shown on one side of the pedal arm **30** and cam block **70**. A second end **100** of the rod is anchored in a valve block (not shown) of the power booster assembly **60**. When the push rod **80** is moved farther into the cylinder **110** a higher brake fluid pressure is achieved in the master braking cylinder (not shown). In this embodiment, the push rod **80** is designed to be longer than a maximum booster or master cylinder stroke.

Cam block **70** includes an outer surface **120** that selectively engages the power booster **60** when the pedal arm **30** rotates toward the power booster assembly. Surface **120** is curved and includes an arc or spline (cam) surface; the surface rotates with respect to a flange **130** on the power booster assembly **60**. The flange **130** has a flat surface. The curved surface **120** on the side of the cam block **70** at least partially translates the rotational energy of the pedal arm **30** into linear movement of the flange **130** on the power booster assembly **60** when the pedal arm is rotated forward with respect to the vehicle.

FIG. **2** illustrates a partial cross-sectional view of the vehicle braking assembly **10** of FIG. **1**, highlighting the power booster **60** and pedal arm **30** engagement. FIG. **2** is a focused side view of the booster-to-pedal-arm engagement for the braking assembly **10**. In the shown embodiment, the pedal arm **30** and power booster assembly **60** are commonly coupled to a bracket **140**. Bracket **140** is coupled to a vehicle structure. Pedal arm **30** rotates with respect to bracket **140** about point **40**. A return spring **150** is included in the braking assembly **10** to apply a restorative force to the pedal arm **30** when moving from an applied position to an unapplied position.

In FIG. **2**, the incorporation of cam block **70** in the pedal arm **30** is shown. Cam block **70** is formed to be one singular piece with the pedal arm **30**. The curved surface of the cam block **70** extends beyond a forward surface **160** of the pedal arm **30** to engage the flange **130** on the push rod **80**. The push rod **80** extends through an orifice **170** in bracket, the cylinder **110** or strut is attached thereto through fasteners **180**. A shell **190** of the power booster assembly houses a diaphragm and valve block (not shown) in fluid communication with the master cylinder of the hydraulic braking system.

There is a gap or spacing, “X”, between the cam block **70** and the flange **130** as shown in FIG. **2**. The pedal arm **30** rotates partially through its arc of rotation without engaging the flange **130**. This gap, X, delays the response from the power booster assembly **60**—and in some instances the hydraulic braking system—when the pedal **20** (as shown in FIG. **1**) is applied. With this gap, X, the push rod **80** does not move linearly but extends further through the pedal arm **30**. The gap, X, enables regenerative braking to take effect and the rotational energy of the wheels to be harvested before the friction brakes are applied. The gap distance can change to adjust to vehicle specifications or user demands. The gap can be larger or smaller than the gap illustrated in FIG. **2**. An exemplary gap is 9-12 millimeters which can translate to approximately 0.2 Gs deceleration. Either or both of the cam block **70** and flange **130** position can be altered to adjust the size of the gap. Cam block **70**, for example, can be moved forward with respect to the vehicle to reduce the size of the gap. Also as an example, flange **130** can be positioned farther away from cam block **70** when the pedal arm **30** is in an unapplied position to increase the gap size.

FIG. **3** is another cross-sectional view of the vehicle braking assembly of FIG. **2**. The section parses through the power booster assembly **60** and illustrates how the push rod **80** is inserted through a guide **200** formed in the cam block **70**. Push rod **80** can be inserted into the cam block **70** through guide **200**. In this manner, guide **200** and push rod **80** are matable or compatible components. Guide **200** includes a tapered surface **210** formed in the cam block **70**. A first end of the guide **200** defines an orifice **220** and the second end of the guide defines a smaller orifice **230**. In this embodiment, the tapered surface **210** has a conical shape. The cone is approximately defined by a surface angled 45 degrees with respect to orifice **230**. The conical surface **210** can have a wider or narrower construction. In another embodiment the conical surface **210** is defined by a surface angled between 10 and 170 degrees with respect to orifice **230**.

The tapered surface **210** of the guide **200** directs the push rod **80** through orifice **240** in the pedal arm **30**, as shown in FIG. **3**. The cam block **70** includes two rounded corners **250** at orifice **230** that ease the push rod’s ability to slide and rotate with respect to the guide **200**. Each corner **250** has a rounded corner or surface with a radius of curvature. The rounded corners enable the push rod **80** to rotate against the cam block **70** and pedal arm **30**. As the pedal arm **30** is rotated towards the booster assembly **60**, the push rod **80** also rotates about corner **250**. A relief surface **235** is provided on the opposite end of corner **250** as the tapered surface **210**. Push rod **80** rotates with respect to a ball joint in the booster assembly **60** and corner **250** against relief surface **235**. In the shown embodiment, rotation of the pedal arm **30** is not coextensive with the rotation of the push rod **80** as some of the rotational energy of the pedal arm is translated to the flange **130** on push rod. In other embodiments, the cam block **70** is configured to enable greater or lesser rotation of the push rod **80** with respect to the pedal arm **30**.

The flange **130**, as shown in FIG. **3**, is an interface surface **260** fixed with respect to the push rod **80**. When flange **130** is engaged with the cam block **70**, the push rod **80** moves with respect to a valve block housed in the power booster assembly **60**. Flange **130** is a flat, solid member. In another embodiment, flange **130** is a hollow member. Flange **130** has a significantly larger cross-sectional area than the push rod **80**, with respect to a longitudinal axis of the push rod. Flange **130** has a cross-section designed not to fit into the tapered surface **210** of the cam block **70** and to apply pressure to the forward surface of the power booster **60** when the flange is sufficiently pressed. Though the flange **130** is shown as a square in FIG. **3**, in other embodiment flange can have a rounded surface. With the rounded surface of the flange **130**, the cam block **70** and pedal arm **30** give symmetry to the assembly **60** with respect to the push rod. With a rounded surface on the booster flange **130**, the booster push rod **80** can be restricted from substantially rotating about its axis through a tapered mating surface (e.g., **210**) formed in the pedal arm. The flange **130** is “keyed” to interface with pedal arm **30** in a predetermined position.

In the illustrated embodiment of FIG. **3**, flange **130** is at least partially coated with an insulation material **280**. The material **280** can be spray applied for example. The insulation material **280** reduces noise from the assembly **10** when the flange **130** engages the cam block **70**. Exemplary insulation materials include rubber, foam or plastics. Material **280** can be applied through a plastic over-molded or rubber bumper part fitted on the flange **130**. In another embodiment, the insulation material **280** is applied to a forward surface of the cam block **70**.

A nut **290**, as shown in FIG. **3**, is formed onto the push rod **80** and positioned against the flange **130**. The nut **290** can provide structural support to the flange **130**. In another embodiment, the nut **290** is removed from the assembly **60**.

As illustrated in FIG. **3**, the push rod **80** extends completely through the pedal arm **30**. In this way a clevis is not required to restrict movement of the push rod with respect to the pedal arm; the push rod **80** is sufficiently aligned with the pedal arm **30** regardless of whether the pedal arm is engaged with flange **130**. In FIG. **3**, the pedal arm **30** is shown in an unapplied position and is not engaged with the flange **130** of the push rod. Moreover, once the braking assembly **10** is assembled the push rod **80** remains appropriately aligned with the pedal arm **30** to ensure engagement. The length of the push rod **80** is sufficiently long so that with the booster at maximum stroke and the pedal arm **30** in rest position, the rod does not disengage the pedal arm.

Referring now to FIG. **4**, there is shown therein a side view of a braking assembly **10** of FIG. **1**. The pedal arm **30** and power booster rod **80** are shown traveling from a first position to a second position. The brake assembly **10** is shown in the first position through solid line. The first position is an applied position for the braking assembly **10**. The pedal **20** is pressed from an unapplied position to an applied position. Pedal arm **30** rotates so that the cam block **70** engages the flange **130** as shown. The flange **130** is configured to engage the cam block **70** when the brake pedal **20** is applied and travels a predetermined amount, e.g., 35 millimeters. As pedal **20** is further applied, the pedal arm **30** rotates about point **40** at the top end **50** of the pedal arm **30**. Pedal arm **30** is rotated into the second position, shown in phantom, a further applied position.

Flange **130** is translated forward with respect to the vehicle. Push rod **80** also moves with flange from the first position farther forward with respect to the vehicle into a second position.

Referring now to FIG. **5** there is shown a side view of an exemplary brake pedal arm **300** with cam block **310** according to another embodiment of the present invention. The cam block **310** shape can be made as a curved surface, ramped surface or off-centered radius to reduce pedal travel. The cam block **310** can be positioned along different points of the booster push rod's longitudinal axis to provide different points of contact between the pedal arm **300** and power booster. In the illustrated embodiment, the pedal arm **300** incorporates cam block **310** that has a curved interface surface **320**. A center point **330** for the surface **320** is moved rearward with respect to the vehicle to alter the engagement dynamics between the cam block **310** and a flange **340**. The center point **330** of the surface **320** is moved with respect to the pedal arm **300**. Thus the profile of the cam block **310** defines surface **320** having a variable radius of curvature with respect to the pedal arm **300**. At an upper end **350** of the cam block **310** the radius of curvature with respect to the pedal arm is smaller than the radius of curvature at a bottom end **360** of the cam block. As the surface **320** engages the flange **340** a push rod **370** moves into a power booster. The provided cam block **310** and surface **320** with variable radius of curvature yields brake pedal travel reduction while achieving the same booster travel as, for example, the embodiment discussed with respect to FIGS. **1-4**.

With reference to FIG. **6**, there is shown therein a schematic diagram of side profiles of two cam blocks with respect to a pedal arm. The Y-axis represents a vertical edge of a pedal arm. The X-axis represents a longitudinal axis of a vehicle. Three circular members **380**, **390** and **395** are shown positioned with respect to the Y-axis. Each member **380**, **390**, **395** represents the front profile of a cam block. Cam block **380** has a center point C_1. Cam block **380** has a uniform radius of curvature. The second member **390** represents the profile of a cam block with center point C_2 moved downward with respect to the pedal arm and rearward with respect to the vehicle. The resulting arc on the cam block **390** is a curved surface that has a variable radius of curvature with respect to the y-axis or pedal arm, e.g., R_2, R_2' and R_2'' as shown. Radius R_2 is smaller than R_2' and R_2'' while R_1 is uniform with respect to the y-axis and pedal arm. The third member **395** represents the profile of a cam block with center point C_3 only moved downward with respect to the y-axis or pedal arm. The third member **395** has a uniform radius of curvature equal to the radius of member **380** (R_1). In this way, the space or gap between cam block surfaces and a pedal arm is consistent between the profile designs of cam blocks **380** and **395**, yet the gap is greater for the position of cam block **390**. Movement of the center point of the cam block surface provides different levels of pedal-ratio variability.

Referring now to FIG. **7** there is shown therein is a top cross-sectional view of a vehicle braking assembly **400** according to another exemplary embodiment of the present invention. The braking assembly includes a cam block **410** that is configured to move with respect to a pedal arm **420**. In this manner, the braking assembly **400** includes a gap management assembly **430**. Cam block **410** is configured to rotate with respect to the pedal arm **420**. The assembly **400** includes two pins **440** shown inserted through the pedal arm **420**. The cam block **410** includes two bushings **450** on each side. Pins **440** are inserted in bushings **450**. Pin **440** is coupled to the cam block **410** and pedal arm **420**. Cam block **410** has an orifice **460** configured so that a push rod can extend therethrough. Cam block **410** has formed therein a tapered surface **405** to guide push rod **470**. In the shown embodiment, cam block **410** has a flat surface; in another embodiment, the cam block has a curved surface which interfaces an interface surface **480** or flange fixedly attached to the push rod. Where push rod **470** extends through cam block **410** an orifice **415** is formed in pedal arm **420** to enable push rod to selectively extend therethrough. A nut **490** is attached to the rod **470** to provide support to the surface **480**. The block **410** may be rotated, as shown in FIG. **7**, depending on the angle that the booster rod **470** takes during pedal travel. This design leads to a reduction in brake travel while achieving the same booster travel. This concept can also be used to increase pedal travel with the same booster rod travel if required for pedal feel.

FIG. **8** is a side view of a vehicle braking assembly **550** according to another exemplary embodiment of the present invention. In this embodiment, a booster rod **560** is non-rotatable and is restricted from moving angularly. The push rod **560** includes an interface surface **570** angularly positioned with respect to the push rod **560**. In the shown embodiment, the interface surface **570** is positioned at an angle, Θ, which is 90 degrees with respect to the push rod **560**. Interface surface **570** includes two guide flanges **580** that extend along the longitudinal axis of the push rod **560**. Guide flanges **580** are positioned with respect to the interface surface **570**. Guide flanges **580** steer or direct pedal arm **590** into engagement with the interface surface **570** in instances where the pedal arm may be misaligned with the interface surface. A cam surface **600** is formed onto the pedal arm **590**. Thus, design and assembly tolerances for the pedal arm **590** and push rod **560** are increased. This embodiment increases the ease of assembly and decreases the required packaging space for the pedal assembly and booster. The simpler design also reduces part costs. The push rod **560** does not need to extend through the pedal arm **590**.

A pedal **610** is attached to a pedal arm **590**. Pedal arm **590** includes the cam surface **600** integrally formed therein. In this manner cam surface **600** is coupled to the pedal arm **590**. Cam surface **600** translates the rotational energy of the pedal arm **590** to the linear movement of the push rod **560**.

There is a spatial distance or gap, "X", between the cam surface **600** and the interface surface **570** as shown in FIG. **8**. The pedal arm **590** rotates partially through its arc of rotation without engaging the interface surface **570**. This gap, "X", delays the response from the power boosters and the hydraulic braking system when the pedal is applied. The gap distance can change to adjust to vehicle specifications or user demands. The gap can be larger or smaller than the gap illustrated in FIG. **8**. An exemplary gap is 6 mm. Either or both of the cam block surface and interface surface **570** can be altered to adjust the size of the gap.

FIG. **9** is a top cross-sectional view of the push rod **560** shown in FIG. **8**. As shown, the push rod **560** includes an interface surface **570** angularly positioned with respect to the push rod. In the shown embodiment, the interface surface **570** is positioned at a 90 degree angle with respect to the push rod **560**. Interface surface **570** includes two guide flanges **580** that extend along the longitudinal axis of the push rod **560**. Two guide flanges are angularly positioned with respect to the interface surface **570** as shown in FIG. **9**. In the shown embodiment, the guide flanges **580** are positioned at an angle, α, which is 20 degrees with respect to the longitudinal axis of push rod **560**. Guide flanges **580** steer or direct pedal arm **590** into engagement with the interface surface **570** in instances where the pedal arm may be misaligned with the interface surface. Thus, design and assembly tolerances for the pedal arm **590** and push rod **560** are increased. This embodiment increases the ease of assembly and decreases the required packaging space for the pedal assembly and booster. The simpler design also reduces part costs.

In an alternative embodiment, a push rod **650** is provided that has a flat interface surface **660**. As shown in FIG. **10**, the push rod **650** includes an interface surface **660** that is flat and fixed with respect to push rod **650**. Surface **660** is angularly positioned with respect to the push rod. In the shown embodiment, the interface surface **660** is positioned at an angle, Θ, which is a 90 degree angle with respect to the push rod **650**. The push rod **650** does not require guide flanges as the surface **660** is sufficiently wide so as to accommodate pedal shifting (i.e., side-to-side) with respect to the push rod **650**.

Referring now to FIG. **11**, there is a side view of a vehicle braking assembly **700** according to another exemplary embodiment of the present invention. In this embodiment, the booster rod **710** is non-rotatable and is restricted from moving angularly. The push rod **710** includes an interface surface **720** angularly positioned with respect to the push rod. In the shown embodiment, the interface surface **720** is positioned at an angle, Θ, which is 90 degrees with respect to the push rod **710**. Interface surface **720** includes two guide flanges **730** that extend along the longitudinal axis of the push rod **710**. This embodiment increases the ease of assembly and decreases the required packaging space for the pedal assembly and booster. The simpler design also reduces part costs.

Guide flanges **730** are positioned with respect to the interface surface **720**. Guide flanges **730** steer or direct pedal arm **740** into engagement with the interface surface **720** in instances where the pedal arm may be misaligned with the interface surface. A cam surface **750** is formed onto the pedal arm **740**.

A roller **760** is also coupled to the pedal arm **740** and configured to engage with the interface surface **720**, as shown in FIG. **11**. The roller **760** translates the rotational energy of the pedal arm **740** to the linear movement of the push rod **710**. A pedal **770** is attached to a pedal arm **740**.

There is a spatial distance or gap, “X”, between the roller **760** and the interface surface **720** as shown in FIG. **11**. The pedal arm **740** rotates partially through its arc of rotation without engaging the interface surface **720**. This gap, “X”, delays the response from the power boosters and the hydraulic braking system when the pedal is applied. The gap distance can change to adjust to vehicle specifications or user demands. The gap can be larger or smaller than the gap illustrated in FIG. **11**. An exemplary gap is 9-12 millimeters. Either or both of the roller **760** and interface surface **720** can be altered to adjust the size of the gap.

FIG. **12** a side view of a vehicle braking assembly **800** with movable cam block **810** according to another exemplary embodiment of the present invention. This embodiment includes a gap management system **820** or assembly that manages or controls the gap, “X”, or spatial distance between a pedal arm **830** and power booster **840**. When disengaged the cam block **810** and power booster **840** define a distance therebetween, shown as “X” in FIG. **12**. The gap management system **820** is configured to alter the distance between the pedal arm **830** and power booster **840** under predetermined conditions. For example, in one embodiment when the assembly **800** is no longer able to operate in the by-wire mode, the gap management system **820** moves the cam block **810** to a position that is closer to the power booster **840**. Since in this embodiment the vehicle is not utilizing regenerative braking resources in this mode it can be undesirable to have a significant spatial distance between the pedal arm **830** and the power booster **840**.

In the illustrated embodiment of FIG. **12**, the braking assembly **800** includes a brake pedal **850** that is coupled to the pedal arm **830**. Pedal arm **830** is configured to rotate with respect to a vehicle structure, pivoting about point **860**. Pedal arm **830** engages the power booster **840**. The power booster **840** includes an interface surface **870** configured to engage a portion of the pedal arm **830**. The pedal arm **830** includes a cam block **810** attached through a spring-loaded fastener (screw or guide pin **910**) onto the pedal arm; cam block **810** sits on the angled surface of a wedge **995**. In the illustrated embodiment, the wedge **995** is on a forward surface **880** of the pedal arm **830**, approximately one third down the vertical axis of the pedal arm. The spatial distance, labeled as “X” between the cam block **810** and surface **870** of the power booster **840** can be changed by changing the position of the cam block **810** with respect to the pedal arm **830**. The block **810** is configured to move with respect to the pedal arm **830** and in this way can change the distance between the pedal arm and power booster **840**, i.e., managing the gap therebetween.

The cam block **810**, as shown in FIG. **12**, is movable with respect to the pedal arm **830** in a horizontal direction, “H.” In this embodiment, drive assembly **900** has at least one spring that is configured to propel the wedge **995** upwards thereby sliding the cam block **810** towards engagement with the power booster **840**.

Drive assembly **900** is shown in the embodiment of FIG. **12**. Drive assembly **900** includes a spring-loaded solenoid **960**. Drive assembly **900** is configured to move the wedge **995** in a vertical direction with respect to the pedal arm **830**. Wedge **995** includes a guide **990** on a front surface which is angularly position with respect to a vertical axis “V”. In the shown embodiment, Θ is approximately equal to 15 degrees. Guide member **990** directs cam block **810** frontward with respect to the vehicle when the drive assembly **900** applies an upward extending force against the cam block **810** due to the spring **940**. Guide member **990** directs cam block **810** rearward when the drive assembly **900** applies a downward extending force against the cam block. Though the guide member **990** is shown coupled to the wedge **995**, guide member can be detached from wedge or formed therein. Cam block **810** is attachable to guide **990** and configured to slide with respect to the guide when the wedge **995** is moved vertically. Wedge includes a slot **1005** formed therein. The slot **1005** enables the wedge to move with respect to a screw **910** to which the cam block **810** is attached. A reaction surface **1015** is formed in the pedal arm **830** which reduces the friction against the wedge **995** as it slides with respect to the pedal arm.

Drive assembly **900** includes an actuator **970** configured to actuate the solenoid **960**. A spring **1000** is also included in the drive assembly **900** of FIG. **12**. Spring **1000** is journaled onto the solenoid **960**. Spring **1000** is configured to bias the wedge **995** towards an upward position with respect to the pedal arm **830**. Cam block **810** is biased against engagement with the power booster **840** by the spring **940**. A latching mechanism **1010** is included in the assembly **900** and configured to selectively secure the spring **1000** in a predetermined position with respect to the pedal arm **830**. Latching mechanism **1010** is releasable from the spring **1000** to enable spring to apply a force against the wedge **995**. Latching mechanism **1010** is linked to the actuator **970** which controls the release of the latching mechanism as well as the solenoid **960**. When the braking assembly loses power spring **1000** can still move wedge **995** upward and the cam block **810** closer to the power booster **840** through the release of latching mechanism **1010**. If Θ is kept at a predetermined amount, e.g. less than 10 degrees depending on material combinations, the latching mechanism **1010** can be inactive and the wedge **995** can act as a self-locking mechanism, not sliding due to frictional forces.

The gap management system **820** is configured to release the cam block **810** into a position that is closer to the power booster **840** under predetermined conditions. The gap management system **820** of FIG. **12** is configured to decrease the spatial distance, "X", between the pedal arm **830** and booster **840** when the assembly **800** can no longer operate in the by-wire mode. The drive assembly **900** will release the cam block **810** and the spring **1000** will push the cam block **810** toward engagement with interface surface **870**. This will minimize the gap between the pedal arm **830** and the booster **840** which will reduce the amount of extra travel required to activate the booster.

Also included with the present teachings are various methods **1100**, **1200** of manufacturing vehicle braking assemblies. Referring now to FIG. **13** there is a flowchart illustrating a method of manufacturing a vehicle braking assembly **1100** according to an exemplary embodiment of the present invention. The method **1100** includes the steps of: providing a pedal **1110**; providing a pedal arm configured to pivot with respect to the vehicle **1120**; coupling the pedal to the pedal arm **1130**; forming a cam block configured to engage a power booster **1140**; and coupling the cam block to the pedal arm **1150**. Exemplary braking assemblies are shown with respect to FIGS. **1**-**12**. Coupling the pedal to the pedal arm can be performed using known attachment techniques such as casting, welding, using fasteners or other techniques. Cam block can be similarly coupled to the pedal arm or can be integrally formed with the pedal arm as well, as shown for example with respect to FIGS. **8** and **11**. Cam block can also be coupled to the pedal arm in a manner to move with respect to the pedal arm, as shown for example in FIGS. **7** and **12**. In another embodiment, the method includes forming a guide in the cam block. The guide is configured to mate with a power booster push rod.

FIG. **14** is a flowchart illustrating a method of manufacturing a vehicle braking assembly **1200** according to an exemplary embodiment of the present invention. The method **1200** includes the steps of: providing a pedal **1210**; providing a pedal arm configured to pivot with respect to the vehicle **1220**; coupling the pedal to the pedal arm **1230**; providing a power booster configured to engage the pedal arm **1240**; and providing a gap management device configured to control the spatial distance between the pedal arm and power booster when not engaged **1250**. Exemplary gap management devices are illustrated, in FIGS. **7** and **12**. Gap management devices are configured to control the spatial distance between the pedal arm and power booster. In one embodiment, the method includes forming a block in the pedal arm; and configuring the block to move with respect to the pedal arm. The block can be a cam block as shown in FIG. **12** for example.

The method can also include: providing a drive assembly configured to move the block with respect to the pedal arm under predetermined conditions. Drive assembly can include a spring-loaded solenoid as shown, for example, with respect to FIG. **12**. Drive assembly can also include other devices such as levers or propellants. In one embodiment, the method also includes coupling a guide member, configured to direct the block, to the pedal arm. Guide member can be, for example, formed in the pedal arm or attached thereto as shown in FIG. **12**.

The disclosed braking assemblies can be composed of, for example, a metal or hard plastic, for example. The illustrated cam blocks are composed of a hard plastic and can be attached to pedal arm using a fastener such as clips, bolts or rivets. In another embodiment, a cam block is molded with the pedal arm. Exemplary material selections for the components of the assemblies include aluminum alloys, steel, and titanium alloys. The disclosed braking assemblies relate to by-wire braking assemblies. The braking assemblies and features are, however, compatible with conventional brake assemblies and not limited to by-wire braking assemblies. While the shown embodiments include a spatial distance between the power booster and the pedal arm, other embodiments of the teachings herein do not include a distance therebetween but are still within the scope of the present invention.

It will be apparent to those skilled in the art that various modifications and variations can be made to the methodologies of the present disclosure without departing from the scope of its teachings. Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the teachings disclosed herein. It is intended that the specification and examples be considered as exemplary only.

While the best modes for carrying out the invention have been described in detail, those familiar with the art to which this invention relates will recognize various alternative designs and embodiments for practicing the invention within the scope of the appended claims.

We claim:

1. A vehicle brake pedal assembly comprising:

a pedal arm having a pivot end, a free end, and a cam surface integrally formed therebetween;

a power brake booster having a push rod including an interface surface that is spaced from the cam surface by a gap in an unapplied position and contacts the cam surface in an applied position; and

first and second guide flanges, each extending from opposing ends of the interface surface.

2. The assembly of claim **1**, wherein movement of the pedal arm through the gap prior to reaching the applied position enables a by-wire braking system in which regenerative braking occurs, and wherein movement of the pedal arm past the gap and to the applied position enables the power brake booster to activate friction brakes.

3. The assembly of claim **1** wherein the first guide flange and the second guide flange extend from opposite sides of the interface surface at an angle (a) to direct the pedal arm into engagement with the interface surface.

4. The assembly of claim **3** wherein the angle (a) is 20 degrees with respect to a longitudinal axis of the push rod.

5. The assembly of claim **1** wherein movement of the pedal arm through the gap prior to reaching the applied position delays actuation of hydraulic brakes via the power brake booster when the pedal arm is moved through the gap.

6. The assembly of claim **1** wherein the gap has a distance (X) that may be adjusted to change the time required for the cam surface of the pedal arm to contact the interface surface.

* * * * *